

Dynamic Design: The Cleanroom

Suiting Up

STUDENT TEXT

FROM DUST BUNNIES TO BUNNY SUITS



You know those dust bunnies that are hiding under your bed? Guess what their key ingredient is. You! Well, that part of you known as skin flakes. Suiting up for the Genesis cleanroom means putting on a bunny suit. Buy why? Why do scientists who work in a cleanroom have to wear a specific type of clothing called a bunny suit*? As you read the following text, you will see that it's all in the threads.

The major source of contamination in the cleanroom originates from the workers. So, if the workers are not properly gowned all the time, the money spent to develop a cleanroom is wasted. Airborne micro-organisms, which are almost exclusively bacteria, are normally dispersed into the air around us from the surfaces of our skin cells. Cleanroom garments help to eliminate this source of contamination by acting as a "person filter" to prevent human particulate matter from entering the atmosphere of the cleanroom.



**Why is it called a bunny suit? There is no hard data to tell us who coined the term or when it was first used. However, speculation suggests that suiting up in the one-piece coverall is much like the suit many of us have seen as costumes and/or pajamas. It's big, it's one color, and it represents a bunny. And no, the cleanroom bunny suit does NOT have long ears and a fuzzy pink tail!*



A cleanroom scientist wears a bunny suit.

Johnson Space Center

IT'S IN THE THREADS

Look at what you are wearing right now. Think about the types of clothing that you, your friends, family, and neighbors wear. Now think about the messages that different types of clothing send. The clothes that you choose to wear often tell others a lot about you. They can reflect gender, locale, age, hobbies, individuality, history, and the type of work that you do. Before we look at cleanroom attire, let's first look at a universal item of clothing that one out of two students who read this are wearing right now—jeans.

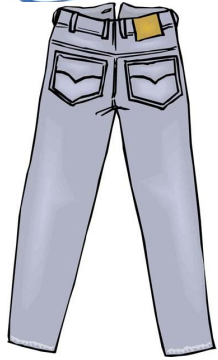


125+ YEARS OF HISTORY

Levi Strauss and Company makes the only 19th century garment that is still worn today. Have you ever worn a pair of jeans? They have a quite a design story.

A young immigrant merchant named Levi Strauss came to San Francisco in 1853 at the age of twenty-four. He opened a dry goods business and among other things, sold bolts of cloth to tailors and manufacturers. Over the next 20 years, Levi built his business into a successful operation.

Jacob Davis was a tailor who regularly purchased bolts of cloth from Levi. Davis had a difficult customer who kept ripping the pockets of the pants that were made for him. One day Davis hit upon the idea of putting metal rivets at points of strain: pocket corners, base of the button fly, etc. His new riveted pants were an instant hit with everyone. Davis began to worry that someone might steal his new trouser design. So, he decided to take out a patent on the process. However, he had a problem. He didn't have the \$68 that was needed to file the papers. What he needed was a business partner, and he immediately thought of Levi Strauss.



The rest is history. The two men received patent #139,121 from the U.S. Patent and Trademark Office on May 20, 1873. Sometime during this year the first riveted clothing was made and sold. Americans could see the sensibility in a durable pair of pants that would withstand heavy wear. Within a very short time, all types of working men were buying up the innovative new clothing, and spreading the word. “Waist overalls” was the traditional name for the work pants. Today, these riveted, denim waist overalls—what we now call jeans—are still worn as workwear. But the term “jeans” didn’t become a universal term until around 1960 (when the baby boomer generation adopted that name for its favorite pants).

JEANS AND BUNNY SUITS? WHAT’S THE CONNECTION?

But what does the evolution of jeans as first a work garment, and later an all-around item of clothing, have to do with suiting up for the Genesis cleanroom? Believe it or not, there is a connection. Just like Davis and Strauss designed jeans with rivets and from durable cotton to serve a specific purpose, so too did NASA when it designed its first space suit—not made of cotton—and later, when it designed the bunny suit for the Genesis cleanroom. Things like fabric, form, design, comfort, mobility, and practical use all played a part in the design of Davis’ jeans, and later, NASA’s spacesuits. For project Mercury, NASA’s first manned space flight program, NASA’s primary goal was to design a spacesuit that would protect the astronauts from the elements of outer space. Suits could be pressurized (inflated) if the spacecraft cabin decompressed.

But what if NASA needed a suit that would protect the environment from its scientists? This is an entirely different concept for clothing. We wear jeans to protect our skin from external effects. Astronauts wear spacesuits to protect them from the elements of outer space. But Genesis cleanroom scientists wear bunny suits **to protect the cleanroom from them**. Why? Well, here are some astonishing facts.

Did you know that. . .

... a major source of contamination in the air around us comes directly from the largest organ in our body? (Our skin is our body’s largest organ, and accounts for 15% of our body weight.)

... we shed the outer layer of our skin every one to two days?

... skin flakes from our body detach themselves and free-float in the air at the rate of hundreds of thousands each minute?

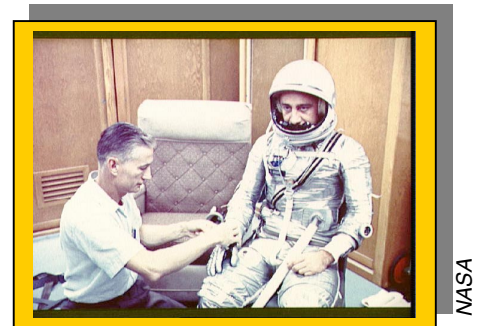
... as these skin flakes become airborne, they break up, much like a falling autumn leaf, and thus multiply in the air around us?

... heat from our bodies increases the air speed of these airborne flakes?

... activity increases the number of flakes that we shed? At rest, we shed approximately 100,000 flakes per minute. Climbing stairs, that rate increases to 10,000,000 skin flakes shed per minute.

... the second-greatest source of contamination from our bodies comes from our mouth by coughs and sneezes?

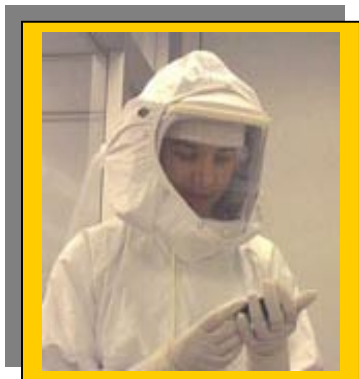
... cross-contamination comes in third as a source of human contamination to our environment? Cross-contamination occurs when we pass contaminants from one place to another.



Astronaut Grissom dons a spacesuit for the Mercury-Redstone 4 mission.

NASA

SO WHAT'S THE BIG DEAL ABOUT CLEANROOM DUDS?



Bunny suits have to protect the cleanroom from the scientists who work inside of it, because workers present the major source of contamination. These suits must be designed to minimize the amount of contamination that enters the cleanroom. The Genesis cleanroom at Johnson Space Center is a class 10 cleanroom. That means that it contains 10 micron-sized particles of contamination for each square foot of the cleanroom.

When the NASA scientists designed the cleanroom bunny suits, they researched the best fabric for the job. They ruled out natural fibers, like cotton, often found in our everyday clothing. But why not cotton? It's a great fabric because it is loosely woven—it breathes.

Cotton allows particles in and out. This would pose a serious problem with contamination control. Thus, you can see why it would not be a good choice for bunny suit fabric. Instead, the fabric of choice is synthetic—meaning that it is man-made. Have you worn—or are you now wearing—polyester, nylon, or another synthetic fabric? How does the way a synthetic fabric feel on a hot day compare to cotton? Steamy, huh? The synthetic fabric in bunny suits is made up of small filaments. It isn't woven. Therefore, synthetics greatly reduced the opportunity for contamination in the cleanroom from all of those skin flakes that we shed. And even with this barrier of protection, particles can still escape into the atmosphere of the cleanroom through the fabric, seams in the fabric, from the surface of the fabric, through zippers, from uncovered portions of the body, and finally, through respiration. The ideal bunny suit fabric should be non-linting, anti-static, chemical resistant, non-flammable, liquid-proof, and comfortable. Common types of bunny suit fabric and their advantage and disadvantages*:

1. *Polyester* - most widely used. It is made of continuous multifilament yarns interwoven with nylon filament thread made conductive by the presence of carbon. Conductive filaments can be worn in a pin-stripe or grid-like pattern. Polyester is non-absorbent, resistant to numerous chemicals and non-linting. However, it is unable to "breathe."
 2. *Teflon Laminated Fabric* - a laminated or bonded fabric with a thin Teflon membrane that can be bonded to the outer layer or manufactured to sandwich an inner layer. When sandwiched, the innermost layer is usually a cotton and polyester blend, allowing for a strong fabric that is an excellent barrier against contamination from the worker, but is also able to "breathe" and repel liquid. However, when bonded to the outer layer the membrane is vulnerable to tears and abrasions, and when sandwiched, the inner fabric layer might contribute to particulate contamination.
 3. *Tyvek* - a lightweight, non-woven material made of spun-bonded polyolefin. It is highly resistant to most acids, bases and oxidizing chemicals. It is also a good barrier against particulate matter, as compared to other woven synthetic materials. In addition to these advantages, it can also be treated with an anti-static agent, and is disposable/washable. The garment loses its anti-static properties after a single wash.
- *See http://www.escoasia.com/tech-centre/library/cleanroom_garments.htm



Ideally, cleanroom workers should be covered with a totally impermeable, non-shedding layer of clothing from head to toe. However, this is not possible. What is the answer? A system that allows the body to maintain a heat balance through normal evaporation and perspiration. Enter: the Genesis mission bunny suit, including coverall, cleanroom shoes, shoe covers, a

head cover, a hood (full coverage or with built-in facemask), and gloves. The Genesis bunny suit is equipped with a HEPA (high efficiency particle air) filter to contain breathing and preserve the cleanliness of the room—specifically to keep those dust bunnies in a bunny suit!

